



Effects of Nanosilver Treatments on Vase Life of Cut Flowers of Carnation (*Dianthus caryophyllus* cv. 'White Liberty')

Yeganeh Basiri, Hossein Zarei* and Kambiz Mashayekhi

*Horticulture Department of Gorgan University of Agricultural Sciences and Natural Resources, Golestan Province, Gorgan, Iran.

Abstract: Carnation (*Dianthus caryophyllus*) is one of the most cultivated flowers around the world for producing of cut flowers. This paper assessed the efficacy of nanosilver (NS) as an antibactericidal agent in extending the vase life of cut flowers of carnation (*Dianthus caryophyllus* L.). Vase solutions were consisting of NS concentrations in 5, 10, 20, 40 and 80 ppm included sucrose 6 percent added in all treatments. Results showed that all NS treatments were combined with sugar extended the vase life of carnation flowers significantly compared with control. Observations indicated that NS treatments inhibited the growth of microorganisms in vase solution and considerably extend the vase life of cut flowers of carnation.

Keywords: Carnation (*Dianthus caryophyllus*), Cut flowers, Nanosilver (NS), Vase Life, Post-Harvest.

1. Introduction

Carnations and Pinks are common or garden names for various species of the genus *Dianthus*, which belongs to the Caryophyllaceae family (Galbally and Galbally 1997; Jurgens *et al.*, 2003a).

The senescence of carnation flowers (*Dianthus caryophyllus* L.) is accompanied by a marked increase in the synthesis of ethylene and a concomitant climacteric rise in respiration (Nichols, 1966). Pre-treatment of cut carnations with a silver thiosulfate complex (STS) prevents the climacteric rise in ethylene production (Veen, 1979) and delays senescence of the flowers (Reid *et al.*, 1980).

Vase life termination for many cut flowers is characterized by wilting (He *et al.*, 2006). The water balance is a major factor determining the quality and longevity of cut flowers. It is influenced by water uptake and transpiration and balance between two mentioned processes (Da Silva, 2003). When the amount of transpiration exceeds the volume of water uptake, water deficit and wilting develop (Halevy and Mayak, 1981). Low water uptake is often due to occlusions located mainly in the basal stem end (He *et al.*, 2006), and microbes are a common cause of stem end blockage (Van Doorn, 1997).

Many agents have been used in cut flowers vase solutions, extends the vase life by improving water uptake. These include silver nitrate (Fujino *et al.*, 1983), aluminum sulphate (Ichimura and Shimizu-Yumoto, 2007) and 8-hydroxyquinoline sulphate (Ichimura *et al.*, 1999). Therefore; it is important to use these materials in vase solutions to extend the vase life of cut flowers.

Nanometer sized silver (Ag^+) particles (NS) are considered to more strongly inhibit bacteria and other microorganisms than Ag in various oxidation states; Ag^0 , Ag^+ , Ag^{2+} , Ag^{3+} (Furno *et al.*, 2004; Jilang *et al.*, 2004). Usage of nanosilver compounds (NS) as a pulse and the vase solution treatment for cut flowers is relatively new (Liu *et al.*, 2009; Solgi *et al.*, 2009) and has demonstrated importance as an antibacterial agent (Alt *et al.*, 2004; Morones *et al.*, 2005). NS releases Ag^+ (Lok *et al.*, 2007), which has been reported to interact with cytoplasmic components and nucleic acids, to inhibit respiratory chain enzymes and to interfere with membrane permeability (Russel and Hugo, 1994; Park *et al.*, 2005). Use of NS is becoming

*Corresponding author:

E-mail: hossein.zarei@ncl.ac.uk, hsszare@yaho.co.uk.

increasingly widespread in medicine, fabrics, water purification and various other industrial and non-plant applications (Jain and Pradeep, 2005; Dubas *et al.*, 2006; Chen and Schuesener, 2008). Liu *et al.*, (2009) reported vase life extension for cut gerbera cv. Ruikou flowers following pulsing with 5mgL^{-1} NS solution for 24h. The positive effect of an NS pulse treatment was attributed to inhibition of bacterial growth in the vase solution and at the cut stems ends during the postharvest period. However, physiological activity of Ag^+ from NS is also a possibility. Ag^+ , generally applied as silver thiosulfate, effectively inhibits ethylene-mediated process, such as flower senescence and abscission (Altman and Solomos, 1995; Ichimura *et al.*, 2008). As with other cations (e.g. k^+ , ca^{2+}), positive effects on plant stem hydraulic conductivity of Ag^+ (Van Ieperen, 2007) is possible. Ohkawa *et al.*, (1999) reported that silver-containing compounds extended the vase life of cut roses. Peitao lu *et al.*, (2010) reported pulse treatment for 1h with 50 and 100mgL^{-1} NS solutions extended vase life and suppressed reduction in fresh weight during the vase period. Kim *et al.*, (2005) reported vase life extensions for Asiatic hybrid *Lilium* cv. Dreamland and Oriental hybrid *Lilium* cv. *siberica* by dipping in a mixture of 0.1% nanoparticle pure colloidal Ag^+ ion, H_2O_2 , and natural chitosan.

With the above research background present study has investigated the effects of NS solution treatments on extending the vase life of cut carnation flowers. Moreover, possibility of change in flower color or any sort of damage to the leaves has been other considerations focused on current research.

2. Materials and Methods

Cut carnation (*Dianthus caryophyllus* L.) flowers were obtained from the Mahallati flower market in Tehran, Iran. Flowers were obtained in a morning of spring (April-May) in 2010. Thereafter, they were kept under shade in the flower mart until being transported within 5h to the Gorgan University of Agricultural Sciences and Natural Resources. To minimize moisture loss, flowers were covered with plastic film during transportation. At the laboratory, stem ends were re-cut by $\geq 10\text{cm}$, and stems with about 25cm long were used in experiments. Experiments were done in a completely randomized design base.

Vase solutions were freshly prepared at the beginning of experiments. Solutions were consisting of NS (Nanocid Company, Iran) concentration of 5, 10, 20, 40 and 80 ppm in combination with sucrose 6% and control treatment was deionized water. Flowers were kept in glass vases containing 250ml solution. Pot mouths were then covered with a sheet polyethylene film to minimize evaporation and prevent contamination. After recording the initial fresh weight, flowers were placed in glass vases filled with the preservative solutions. The flowers were then kept in a

controlled room under the following conditions: 12 h photoperiod at a photosynthetically activated radiation of 850 LUX, provided by fluorescent lamps, constant temperature of $20 \pm 2^\circ\text{C}$ and relative humidity of $60 \pm 10\%$.

Each treatment was comprised six flowers and was repeated three times. Statistical significance between mean values was assessed using analysis of variance (glm) and conventional LSD multiple range test at $p \leq 0.05$. This procedure was carried out with the aid of the SAS 9.1 software platform.

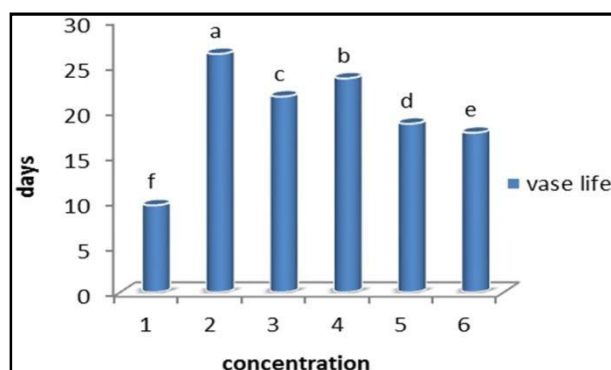
3. Result and Discussion

In current study different concentrations of nanosilver (NS) was used as the main source of variation. The result showed that these preservative solutions could extend the vase life of cut carnations. Significant ($p \leq 0.05$) differences were found among various concentrations of NS in extending the vase life of carnation (*Dianthus caryophyllus* L.) flowers. The longest vase life was obtained with 5 ppm NS (Table 1 and Graph 1). Also, flowers held in all concentrations of NS treatment indicated longer vase lives than control (Table 1).

Table 1. Effect of different concentrations of Nanosilver (NS) on vase life of carnation flowers.

Vase life	Days
Nanosilver concentrations	
NS 5 ppm	26.3 a
NS 10 ppm	21.6 c
NS 20 ppm	23.6 b
NS 40 ppm	18.6 d
NS 80 ppm	17.6 e
Control	9.6 f

(Source: Mean separation among treatments was done by LSD test at $p \leq 0.05$.)



Graph 1.

Table 2 depicts the effect of different concentrations of NS on the vase life of carnation flowers. It can be seen that there are significant differences ($p \leq 0.05$), between quality of flowers and quality of leaves during the post-harvest time and various concentrations of NS. The lowest quality of

flowers and leave was obtained with control treatment (Graph 2). Interaction between time and concentration of vase solution for two mentioned factors was significant at $p \leq 0.05$.

Table 3 shows considerable differences between measuring factories on different concentrations of NS at $p \leq 0.05$.

This table indicates no significant ($p \leq 0.05$) differences were found among various concentrations of NS on absorbed water (Graph 3), Brix of petals (Graph 7), chlorophyll ab, chlorophyll a, chlorophyll b in leaves and kartenoides of flowers (Graph 5). But during the time (except for kartenoid), differences between measuring factors were found to be significant at ($p \leq 0.05$). Moreover, our experiments indicated that there was a significant difference between bacteria concentration and various concentrations of NS at $p \leq 0.05$. The lowest bacteria concentration was obtained with 5 ppm nanosilver (Graph 6). And the highest concentration rate was seen with Control treatment.

Table 2. Effect of different concentrations of NS on vase life of carnation flowers.

Treatment	df	QL	QF
R	216	0.1378	0.0548
Density	5	<.0001	<.0001
Time	5	<.0001	<.0001
Density*time	25	<.0001	<.0001
Cv		0.81	3.609

(Source: Mean separation among treatments was done by LSD test at $p \leq 0.05$. QL= quality of leaves; QF= quality of flower)

In addition, there was no significant effect between different level of NS concentrations and relative fresh weight of cut carnation flowers. Maximum of fresh weight was observed in flowers kept in the solutions which contained 80 ppm NS (Table 4 and Graph 4).

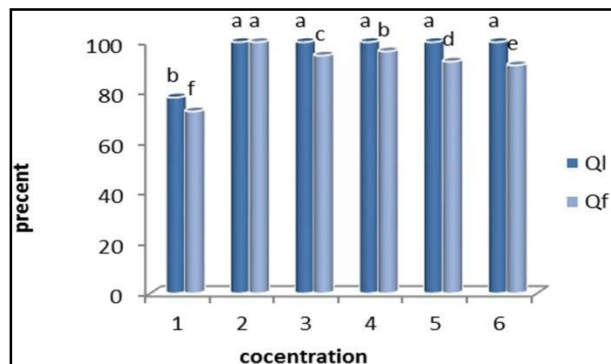
According to a literature review of current studies, adding sucrose to preservative solutions had positive effects on the vase life of most flowers, such as carnation (Halevy and Mayak, 1979).

The results of the current study indicated that a combination of sucrose and nanosilver compound extends vase-life of cut carnation (*Dianthus caryophyllus*). So, it can be concluded that NS has antibacterial effects and can extend the vase life of cut carnation.

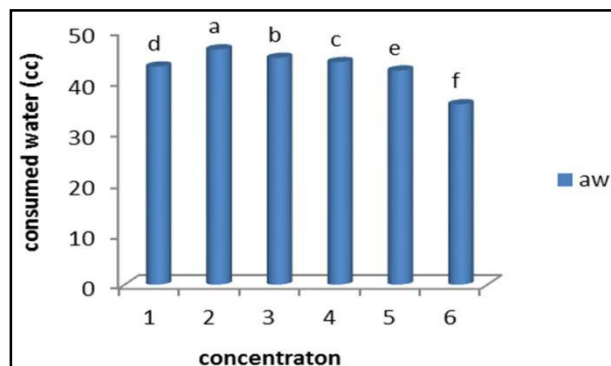
5 and 20 ppm NS in combination with sucrose 6% extended the vase life of cut flowers of white carnation by 26.3 and 23.6 days (Table 1 and Graph 1).

Observations indicated that NS treatments had no effect on the color changes of petals on carnation cut flowers.

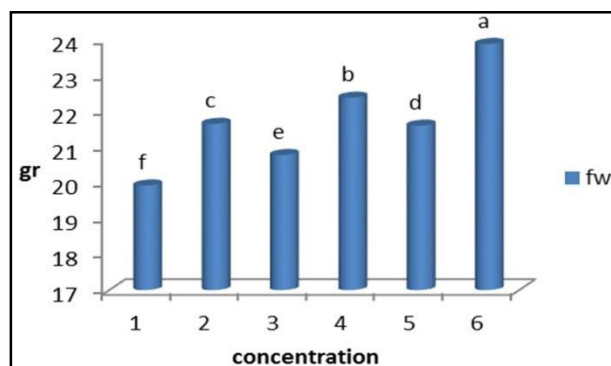
Moreover, our experiments indicated that NS treatments had a positive effect on increasing quality and vase life of cut flowers leaves of carnation Table 2, Graph 2).



Graph 2.



Graph 3.



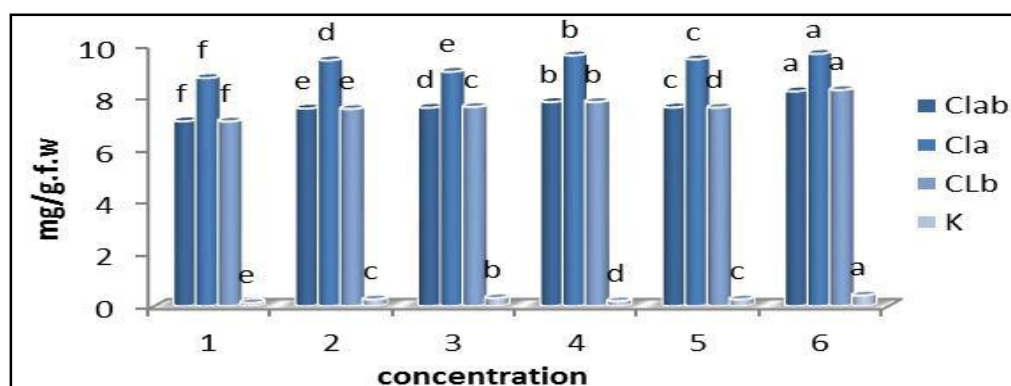
Graph 4.

Table 3. Effect of different concentration of Nanosilver (NS) on vase life and measured factors of carnation flowers.

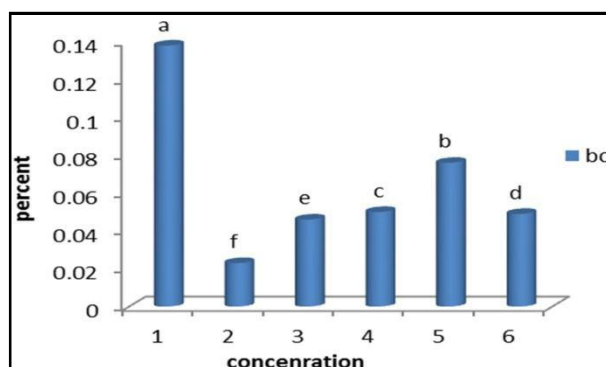
Treatment	df	aw	bc	B	Clab	CLb	Cla	K
R	48	0.3507	0.4095	<.0001	<.0001	<.0001	0.0023	0.1846
Density	5	0.3530	<.0001	0.7640	0.7001	0.6720	0.8443	0.6404
Time	5	<.0001	0.2203	<.0001	<.0001	<.0001	<.0001	0.0123
Time * Density	24	0.0233	<.0001	<.0001	<.0001	<.0001	0.0100	0.7362
Cv		18.10	34.73	4.103	6.38	6.53	9.35	124.7

(Source: Mean separation among treatments was done by LSD test at $p \leq 0.05$).

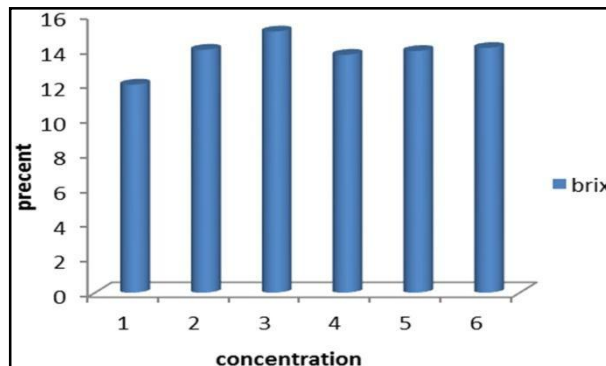
aw= absorb water; bc= bacteria concentration; b= Brix (TSS); Clab= chlorophyll ab; CLa= chlorophyll a; CLb=chlorophyll b; K= kartenoid.



Graph 5.



Graph 6.



Graph 7.

Table 4. Effect of different concentration of Nanosilver (NS) on vase life and relative fresh weight of carnation flowers.

Treatment	Df	Fw
R	108	0.0050
Density	5	0.0012
Time	2	<.0001
Density*time	10	<.0001
Cv		15.549

(Source: fw= fresh weight)

Nanosilver as a pulse and the vase solution treatment for cut flowers is relatively new (Liu *et al.*, 2009; Solgi *et al.*, 2009) and has demonstrated its importance as an anti-bactericidal agent which was improved with current study (Alt *et al.*, 2004; Morones

et al., 2005). Ohkawa *et al.*, (1999) reported that silver-containing compounds extended the vase life of cut roses. The positive effect of an NS pulse treatment was attributed to inhibition of bacterial growth in the vase solution and at the end of cut stems during the first two days of the post-harvest period which was confirmed with current study too. However, physiological activity of Ag^+ from NS is also a possibility which needs more investigation.

4. Conclusion

In this study indicate that nanosilver delays flower senescence in 'White Liberty' carnation. This increasing on quality and vase life of cut flowers petals and leaves of carnation is caused by decreasing of bacteria concentration and various concentrations NS on vase solutions. Moreover that NS treatment had a positive effect on increasing quality and vase life of cut flowers of carnation (*Dianthus caryophyllus* L.).

References

- [1]. Altman, S.A., Solomos, T. (1995). Differential respiratory and morphological responses of carnations pulsed or continuously treated with silver thiosulfate. *Postharvest Biol. Technol.*, 5: 331-343.
- [2]. Alt, V., Bechert, T., Steinrucke, P., Wagener, M., Seidel, P., Dingeldein, E., Domann, E., Schnettler, R. (2004). An *in vitro* assessment of the antibacterial properties and cytotoxicity of nanoparticulate silver bone cement. *Biomaterials*, 25: 4383-4391.
- [3]. Chen, X., Schluesener, H.J. (2008). Nanosilver: a nanoparticle in medical application. *Toxicol. Lett.*, 176: 1-12.
- [4]. Da Silva, J.A.T. (2003). The cut flower: post-harvest considerations. *J. Biol. Sci.*, 3: 406-442.
- [5]. Dubas, S.T., Kumlangdudsana, P., Potiyaraj, P. (2006). Layer-by-layer deposition of antimicrobial silver nanoparticles on textile fibers, *Colloids Surf. A: Physicochem. Eng. Aspect* 289: 105-109.

- [6]. Fujino, D.W., Reid, M.S., Kohl, H.C. (1983). The water relations of maidenhair fronds treated with silver nitrate. *Sci. Hort.*, 19: 349-355.
- [7]. Furno, F., Morley, K.S., Wong, B., Sharp, Arnold, P.L., Howdle, S.M., Bayston, R., Brown, P.D., Winship, P.D., Reid, H.J. (2004). Silver nanoparticles and polymeric medical devices: a new approach to prevention of infection? *J. Antimicrob. Chemother.*, 54: 1019-1024.
- [8]. Galbally, J. and Galbally, E. (1997). Carnations and pinks for garden and greenhouse, Timber Press, Portland, Oregon, USA. Pp 1-310.
- [9]. Halevy, A.H., Mayak, S. (1981). Senescence and postharvest physiology of cut flowers, 2. *Hort. Rev.*, 3: 59-143.
- [10]. He, S., Joyce, D.C., Irving, D.E., Faragher, J.D. (2006). Stem end blockage in cut *Grevillea* 'Crimson Yullo' inflorescences. *Postharvest Biol. Technol.*, 41: 78-84.
- [11]. Ichimura, K., Kojima, K., Goto, R. (1999). Effects of temperature, 8-hydroxyquinoline sulphate and sucrose on the vase life of cut rose flowers. *Postharvest Biol. Technol.*, 15: 33-40.
- [12]. Ichimura, K., Yoshioka, S., Yumoto-Shimizu, H. (2008). Effects of silver thiosulfate complex (STS), sucrose and combined pulse treatments on the vase life of cut snapdragon flowers. *Environ. Control Biol.*, 46: 155-162.
- [13]. Ichimura, K., Shimizu-Yomoto, H. (2007). Extension of the vase life of cut rose by treatment with sucrose before and during simulated transport. *Bull. Natl. Inst. Flor. Sci.*, 7: 17-27.
- [14]. Jain, P., Pradeep, T. (2005). Potential of silver nanoparticle-coated polyurethane foam as an antibacterial water filter. *Biotechnol. Bioeng.*, 90: 59-63.
- [15]. Jiang, H., Manolache, S., Wong, A.C.L., Denes, F.S. (2004). Plasma-enhanced deposition of silver nanoparticles onto polymer and metal surfaces for the generation of antimicrobial characteristics. *J. Appl. Polym. Sci.*, 93: 1411-1422.
- [16]. Jurgens, A., Witt, T., Gottsberger, G. (2003a). Flower scent composition in *Dianthus* and *Saponaria* species (Caryophyllaceae) and its relevance for pollination biology and taxonomy. *Biochemical Systematics and Ecology*, 31: 345-357.
- [17]. Kim, J.H., Lee, A.K., Suh, J.K. (2005). Effect of certain pre-treatment substances on vase life and physiological character in *Lilium* spp. *Acta Hort.*, 673: 307-314.
- [18]. Liu, J.P., He, S.G., Zhang, Z.Q., Cao, J.P., Lv, P., He, S., Cheng, G., Joyce, D.C. (2009). Nano-silver pulse treatments inhibit stem-end bacteria on cut gerbera cv. Ruikou flowers. *Postharvest Biol. Technol.*, 54: 59-62.
- [19]. Lok, C.N., Ho, C.M., Chen, R., He, Q.Y., Wing, Y.Y., Sun, H., Tam, P.K.H., Chiu, J.F., Che, C.M. (2007). Silver nanoparticles: partial oxidation and antibacterial activities. *J. Biol. Inorg. Chem.*, 12: 527- 534.
- [20]. Morones, J.R., Elechiguerra, J.L., Camacho, A., Holt, K., Kouri, J.B., Ramirez, T.J., Yacaman, M.J. (2005). The bactericidal effect of silver nanoparticles. *Nanotechnology*, 16: 2346-2353.
- [21]. Nichols, R. (1966). Ethylene production during senescence of flowers. *J. Hortic. Sci.*, 41: 279-290.
- [22]. Niemietz, C.M., Tyerman, S.D. (2002). New potent inhibitors of aquaporins: silver and gold compounds inhibit aquaporins of plant and human origin. *FEBS LETT.*, 531: 443-447.
- [23]. Ohkawa, K., Kasahara, Y., Suh, J. (1999). Mobility and effects on the vase life of silver-containing compounds in cut rose flowers. *Hort. Science*, 34: 112-113.
- [24]. Park, S.H., Oh, S.G., Mun, J.Y., Han, S.S. (2005). Effects of silver nanoparticles on the fluidity of bilayer in phospholipid liposome. *Colloids Surf. B: Biointerfaces*, 44: 117-122.
- [25]. Peitao Lu, Jinping Coa, Shenggen He, Jiping Liu, Hongmei Li, Giping Cheng, Yuelian Ding, Daryl C. Joyce, (2010). Nano-silver pulse treatments improve water relations of cut rose cv. Movie Starflowers. *Postharvest Biol. Technol.*, 57: 196-202.
- [26]. Reid, M.S., Paul, J.L., Farhoomand, M.B., Kofranek, A.M., Staby, G.L. (1980). Pulse treatments with the silver thiosulfate complex extend the vase life of cut carnations. *J. Am. Soc. Hortic. Sci.*, 105: 25-27.
- [27]. Russell, A.D., Hugo, W.B. (1994). Antimicrobial activity and action of silver. *Prog. Med. Chem.*, 31: 351-370.
- [28]. Solgi, M., Kafi, M., Taghavi, T.S., Naderi, R. (2009). Essential oils and nanoparticles (SNP) as novel agents to extend vase-life of gerbera (*Gerbera jamesonii* cv. 'Dune') flowers. *Postharvest Biol. Technol.*, 53: 155-158.
- [29]. Van Doorn, W.G. (1997). Water relations of cut flowers. *Hort. Rev.*, 18: 1-85.
- [30]. Van leperen, W. (2007). Ion-mediated changes of xylem hydraulic resistance in planta: fact or fiction? *Trends Plant Sci.*, 12: 137- 142.
- [31]. Veen, H. (1979). Effects of silver on ethylene synthesis and action in cut carnations, *Planta*, 145: 467- 470.